

Comparison of the TE and Field Strength Dependence of Single Shot Image S/N and Time Series Standard Deviation in Humans and Phantoms

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Introduction

It is well known that, among other things, signal to noise ratio is proportional to voxel size, and field strength. In fMRI we collect time series data, so the relevant variable is not the S/N in each image but the S/N over time, as indicated by the standard deviation. This noise is dependent on many things: system stability, physiologic processes such as breathing, heartbeat, motion, and possible spontaneous susceptibility changes related to blood flow. Therefore, assessment of this noise has many practical and theoretical implications. In this study we compare spatial and temporal S/N between 3 T and 1.5 T at 5 different echo times.

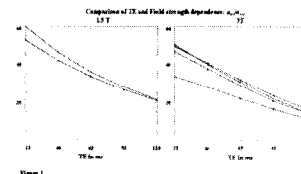
Materials and Methods

MR data were acquired using a 3 T and a 1.5 T General Electric scanner with a standard quadrature head coil. A single-shot spiral (E.C. Wong et. al.) was used for single slice imaging, obtaining 5 images at each readout (TE = 23ms, 46ms, 69ms, 92ms, 115ms, TR=1s). Images were acquired at 24cm FOV, 64x64, and 5cm slice thickness. Images were reconstructed to produce a grid of 128x128. Four water phantom data sets were acquired on both scanners. Four subjects were scanned at 3 T and two of those were scanned at 1.5 T, under an approved IRB protocol. A series of 512 images were obtained for each scan.

Each data set was segregated into 5 subsets corresponding to each echo time. The following measurements were performed in each subset separately. For each voxel in each image the average temporal amplitude (μ) and the temporal standard deviation (σ) of the signal were calculated. μ and σ were averaged over a rectangular region of interest, covering the major part of the head or phantom. The ratio of μ_{av} / σ_{av} was obtained for each echo time.

Results

We observe that the subject μ_{av} / σ_{av} decreases exponentially with TE and it is approximately the same for both field strengths. In phantoms preliminary findings showed that μ_{av} / σ_{av} follows the same exponential decrease with TE, however, μ_{av} / σ_{av} is approximately 35% higher at 3T. The above support the assumption that even though higher fields provide for better SNR and temporal signal stability, physiologic noise appears to be dominant, therefore counteracting higher field benefits. Figure 1 illustrates the results obtained from the subject comparison.



Conclusion

The preliminary results showed that when going to higher field strengths (or even when using surface coils), physiologic noise needs to be filtered out, otherwise one does not gain all the advantages of higher functional contrast and signal to noise, since it is time series fluctuations that dominate the signal variance. Further experiments at both field strengths will be performed comparing image S/N vs. the S/N varying TR, resolution, flip angle, and shorter TE times, as well as spectral analysis to examine frequency components.

References

- [1] F.Q.Ye, J.A. Frank, D.R.Weinberger, A.C. McLaughlin, ISMRM 6th Scientific Meeting Proceedings, 2: 1210 (1998).